CLAIMS

1. A method for processing data used for hydrocarbon extraction from the earth comprising the steps of:

receiving sampled data representing earth structures;

identifying one or more symmetry transformation groups from the sampled data;

identifying a set of critical points from the sampled data;

generating a plurality of subdivisions of shapes the subdivisions together representing the earth structures, the generation being based at least in part on the set of identified critical points and the symmetry transformation groups; and

processing earth model data using the generated subdivision of shapes.

2. A method according to claim 1 wherein the identified symmetry transformation group is a set of diffeomorphisms that act on a topologically closed and bounded region in space-time such that under transformation said region occupies the same points in space.

3. A method according to claim 1 wherein each of the identified symmetry transformation groups corresponds to a plurality of shape families.

4. A method according to claim 3 wherein each of the plurality of shape families comprises a set of predicted critical points.

5. A method according to claim 4 wherein the step of generating subdivisions comprises selecting a shape family from the plurality of shape families that corresponds to the identified symmetry transformation group, said selecting being based on closeness of correspondence between the identified critical points from the sampled data and the predicted critical points of the selected shape family.

6. A method according to claim 5 wherein each shape family has an associated set of symmetry transformation group orbits, some of the orbits being associated with critical points and other orbits being associated with distinguished Gaussian curvature values.

7. A method according to claim 6 wherein each symmetry transformation group orbit of the selected shape family is associated with orbit information that specifies whether the orbit contains a predicted critical point and value of the Gaussian curvature of a point in the orbit.

8. A method according to claim 7 wherein the orbit information from the set of symmetry transformation group orbits associated with the selected shape family is applied to the sampled data thereby generating a unique specification of a shape from the selected shape family.

9. A method according to claim 8 wherein each of the plurality of subdivisions of shapes is generated by identifying a part of the uniquely specified shape that corresponds to the sampled data.

10. A method according to claim 9 wherein the identified parts of the uniquely specified shapes are assembled, thereby generating a representation of the earth structures.

11. A method according to claim 10 wherein the generated representation is continuous.

12. A method according to claim 11 wherein the generated representation is smooth.

13. A method according to claim 9 wherein the uniquely specified shapes are specified using differentiable functions including one or more of the following types: surfaces derived from conic sections, splines, general polynomials and trigonometric functions.

14. A method according to claim 1 wherein the sampled data is smoothed prior to said steps of identifying critical points and identifying one or more symmetry transformation groups.

15. A method according to claim 1 wherein the identified critical points are Morse theoretical height field critical points consisting of the following three types: minima, maxima and saddle points.

16. A method according to claim 15 wherein said step of generating a plurality of subdivisions comprises applying a canonical homogeneous transform such that the number of parameters needed to uniquely describe a shape in the earth structure is minimized.

17. A method according to claim 1 wherein the earth model data is geologic data, geophysical data, petrophysical data, mechanical earth model data and/or reservoir fluid flow data.

18. A method according to claim 1 wherein earth model data is processed such that earth models are updated, alternative versions of existing earth models are created, time-lapse earth models are generated and/or the earth model data is distributed to other earth models or other applications.

19. A method according to claim 1 wherein the sampled data represents sampled physical structure and material properties of the earth structures.

20. A method according to claim 1 wherein said step of processing earth model data comprises making predictions of fluid flow though at least some of the earth structures and wherein the altered activity is altering the rate of extraction based on said predictions.

21. A method according to claim 1 wherein said step of processing earth model data comprises predicting the likelihood of structural failure of a wellbore though at

least some of the earth structures and wherein the altered activity is altering the drilling of the wellbore based on the predicted likelihood of failure.

22. A method according to claim 1 wherein said step of processing earth model data comprises communicating geologic information relating to at least some of the earth structures between a first geometrical representation and a second geometrical representation of the earth structures.

23. A method according to claim 1 wherein said step of processing earth model data comprises aggregating information from a plurality of geometrical representations of the earth structures and wherein the altered activity is based at least in part on the aggregated information.

24. A method according to claim 1 wherein said step of processing earth model data comprises constructing an earth model to a user specified error tolerance using the generated subdivision of shapes.

25. A method according to claim 1 wherein each of the plurality of subdivisions of shapes is generated by identifying a part of a uniquely specified shape that corresponds to the sampled data.

26. A method according to claim 1 wherein the step of generating a plurality of subdivisions comprises the steps of:

analyzing curvature of the sampled data thereby generating a shape index field; and

identifying functions that fit the shape index field.

27. A method according to claim 26 wherein the functions are differentiable.

28. A method according to claim 1 wherein the plurality of subdivisions are generated such that the number of parameters in each subdivision times the number of subdivisions is substantially less than would be needed using a faceted representation method.

29. A method according to claim 1 wherein the plurality of subdivisions are generated such that they are more numerically stable than third order or higher representation.

30. A method according to claim 1 wherein the sampled data is a faceted representation of the earth structures.

31. A method according to claim 30 wherein the faceted representation is a triangle mesh.

32. A method according to claim 30 wherein the faceted representation is a grid.

33. A method according to claim 1 wherein the sampled data is data measured with seismic acquisition equipment.

34. A method according to claim 33 wherein said steps of receiving, identifying one or more symmetry transformation groups, identifying a set of critical

points and generating a plurality of subdivisions of shapes are preformed at or near the location where the sample data is measured.

35. A method according to claim 34 wherein said step of processing earth model data is performed in one or more locations remote from the location where the sample data is measured.

36. A system for improved extraction of hydrocarbons from the earth comprising:

a storage system adapted to receive and store sampled data representing earth structures;

a processing system adapted to identify one or more symmetry transformation groups from the sampled data, identify a set of critical points from the sampled data, and generate a plurality of subdivisions of shapes the subdivisions together representing the earth structures, the generation being based at least in part on the set of identified critical points and the symmetry transformation groups;

an earth model processing system adapted to processes earth model data using said generated subdivision of shapes; and

an interface to output the processed earth model data to an operator.

37. A system according to claim 36 wherein the identified symmetry transformation group is a set of diffeomorphisms that act on a topologically closed and bounded region in space-time such that under

transformation said region occupies the same points in space.

38. A system according to claim 36 wherein each of the identified symmetry transformation groups corresponds to a plurality of shape families, each of which comprises a set of predicted critical points.

39. A system according to claim 38 wherein the subdivisions are generated such that a shape family is selected from the plurality of shape families that corresponds to the identified symmetry transformation group, said selecting being based on closeness of correspondence between the identified critical points from the sampled data and the predicted critical points of the selected shape family.

40. A system according to claim 39 wherein each shape family has an associated set of symmetry transformation group orbits, each orbit being associated with orbit information that specifies whether the orbit contains a predicted critical point and value of the Gaussian curvature of a point in the orbit, and wherein the orbit information from the set of symmetry transformation group orbits associated with the selected shape family is applied to the sampled data thereby generating a unique specification of a shape from the selected shape family.

41. A system according to claim 40 wherein each of the plurality of subdivisions of shapes is generated by identifying a part of the uniquely specified shape that

corresponds to the sampled data, and wherein the identified parts are assembled, thereby generating a representation of the earth structures.

42. A system according to claim 36 as part of a system adapted to assist a decision making process relating to extraction of hydrocarbons from a hydrocarbon reservoir modeled by the processed earth model data.

43. A system according to claim 36 wherein the plurality of subdivisions are generated such that they are more numerically stable than third order or higher representation.

44. A system according to claim 36 wherein the sample data are acquired from the earth structures using seismic acquisition equipment, the storage system and the processing system are located at or near the location where the sample data are acquired, and the earth model processing system is located in one or more locations remote from the location where the sample data is acquired.